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Printing Device

The invention relates to a printing device with an electro-photographic print unit, to which a transfer medium for transferring a toner powder to a substrate in a transfer zone is assigned, wherein the substrate can be conducted through the transfer zone by means of a transport system, wherein heat energy can be introduced into the substrate by means of one or several heating elements.

Such a printing device is known from USP 5,988,068. There, an endlessly revolving belt is assigned to an electro- photographic print unit as the transfer medium. A photoconductor rolls off on the belt for transferring an image consisting of toner powder. The toner image can be applied to a substrate. To this end, the substrate is moved past the transfer medium by means of a transport system. In this case the transfer medium rolls off the substrate surface to be imprinted. For improving the toner transfer, USP 5,988,068 proposes the employment of two heating elements. The first heating element heats the substrate to a temperature higher than 60°C. The second heating element acts on the transfer medium at a temperature higher than 100°C.

With this arrangement it has been found to be disadvantageous, in particular in connection with printing with ceramic toners, that residue from the toner adheres to the transfer medium which, because of the doughy consistency, is hard to remove at this temperature, or cannot be completely removed. Moreover, during constant operation, heat is introduced into the electro-photographic print unit via the transfer medium. This results in the worsening of the image quality.

It is the object of the invention to create a printing device of the type mentioned at the outset, by means of which an improved toner transfer from the transfer medium to the substrate is possible.

This object is attained in that a cooling device is assigned to the transfer medium, which removes heat from the latter. Because of the cooling of the transfer medium it is assured that the toner powder does not adhere to the surface of the transfer medium after the transfer to the substrate has been completed, but instead is released almost completely during the transfer. The introduction of heat into the print unit, in particular at the sensitive photoconductor, is also prevented by the cooling, or is at least minimized to an acceptable degree.

In accordance with a preferred embodiment variation of the invention it has been provided that at the transfer zone formed with the substrate, the transfer medium has a lower temperature, at least in the area of the contact face, than the surface of the substrate. It has then been assured that the flow of heat can take place at most from the substrate to the transfer medium. Then the cooling device removes this heat in a controlled manner, at least in the greatest part.

In accordance with the invention it can be provided that the cooling device cools the temperature of the transfer medium to a temperature $\leq 60°C$. The temperature preferably is less than 40°C. At these temperatures the transfer medium is not heated, even during constant operation, in such a way that the toner powder reacts with the surface of the transfer medium. The toner transfer can be additionally aided in that the toner transfer in the transfer zone can be affected by means of one or several coronas. In the course of this,

electrostatic forces act on the toner powder. For example, it is possible to arrange coronas over large areas upstream and/or downstream of the transfer zone. These then charge the substrate. Alternatively, or additionally, the substrate can also be placed on a conductive base. In contrast to negatively charged toners, the latter is then positively charged. With positively charged toners then correspondingly negatively. The charge voltages can be reduced in an advantageous manner in such a way that negative field effects, such as with an exclusive toner transfer created by means of electrostatic fields, no longer occur.

An additional improvement of the toner transfer can be achieved in that on its surface which receives the toner powder the transfer medium is provided with an anti-adhesive layer, and that this anti-adhesive layer has a surface energy within the range of 15 mN/m to 30 mN/m.

It would be conceivable to use a Teflon coating within the range of 18 to 20 mN/m. In this case the anti-adhesive layer should have a layer thickness in a range between 1 and 100 μm, preferably 5 to 50 μm. A particularly effective heating of the substrate can take place in that the substrate can be charged with heat energy by means of a heating element designed as an infrared radiator and/or a hot air blower and/or by means of the application of a flame. The substrate should be heated in a temperature range between 80°C and 200°C. In a preferred manner, the surface temperature of the substrate in the coating area has been set to more than 100°C to 170°C. In this case, the temperature should be set as a function of the toner used. Tests with ceramic toners having a solids component (pigments, glass frit) of 50 to 70% have shown that a surface temperature of the substrate of 120°C to 150°C is particularly advantageous. Following the conclusion of the transfer, the

toner powder should melt onto the substrate. If the toner powder has been completely melted, a subsequent fixation can possibly be omitted.

On the one hand, the print medium can consist of a matrix of thermoplastic material, into which organic or inorganic color pigments and/or glassy paste particles can be introduced for coloration.

In another case, the plastic matrix consists of a mixture of hardening and binder resins, or of polymers which, at temperatures > 100°C, are reacted to form thermosetting, i.e. spatially cross-linked, structures, into which again organic or inorganic color pigments can be introduced for coloration.

Moreover, other additives can also be contained in it, such as conductive particles or particles of mechanically resistant material, for example, which later on result in an electrically conductive coating or a protective layer against scratches, for example.

Matched to the substrate to be imprinted, it can be necessary to maintain the substrate temperature as low as possible. This is of importance in particular in connection with temperature-sensitive plastic substrates or with glass which is less resistant to temperature changes. In this case it is necessary to adapt the plastic matrix of the print media in such a way that the softening point of the matrix is also lowered. This is of particular interest when, in the case of additives such as ceramic pigments or glass paste particles, the softening temperature rises with an increased proportion of solids in the plastic matrix.

Some examples of toners with ceramic color and glass paste additions:

Toner 1 Proportion of solids 44 wt-% Softening temp. 98°C

Toner 2 Proportion of solids 58 wt-% Softening temp. 104°C

Toner 3 Proportion of solids 71 wt-% Softening temp. 113°C

A reduction of the softening temperature in case of an increased proportion of solids is provided, on the one hand, by adding polymer additives, such as wax, or by using a different low-melting plastic matrix.

The indicated softening temperatures relate to measurements by means of a Shimazu viscosity measuring device Type CFT-500 c.

(Measuring conditions: Supported weight 10 kg

Nozzle diameter 0.5 mm

Nozzle length 1 mm

Plunger surface 1 cm^2

Start temperature 80°C

Heating rate 3 k/min).

To achieve a control of the substrate temperature, it can be provided that a temperature sensor is assigned to the substrate, and that the heating element and/or the transport system can be controlled by means of a control device as a function of the signal emitted by the temperature sensor.

In this case the temperature can be regulated by acting on the transport system via the retention time of the substrate in the heating zone, or via the speed of its passage.

Regulation preferably takes place in that the substrate enters the transfer zone always at a constant surface temperature. During the transfer, the substrate surface should be evenly heated.

To achieve an effective heat regulation of the transfer medium, it can be provided that one or several liquid-cooled contact rollers of the cooling device roll off on the transfer medium, and/or that a climate-controlled air flow is directed onto the surface of the transfer medium.

It is also conceivable for the transfer medium to be embodied as a transfer roller which contains at least a portion of the cooling device. In this case the cooling device can also contain one or several Peltier elements. Alternatively or additionally, the transfer roller can also be water-cooled or air-cooled.

If it is provided that the cooling device removes heat energy from the transfer medium downstream of the transfer zone and upstream of the photoconductor of the print unit in the transport direction of the transfer medium, the introduction of heat into the photoconductor is dependably prevented.

The invention will be explained in greater detail in what follows by means of an exemplary embodiment represented in the drawings. Shown are in:

Fig. 1, a printing device in a schematic representation,

Fig. 2, a transfer medium with an associated cooling device, also in a schematic representation,

Fig. 3, a transfer medium with interior cooling.

A printing device with an electro-photographic print unit 30 is represented in Fig. 1. It has a cylinder-shaped photoconductor 32. It is provided with a uniform charge on its surface in a charge station 31.1. This charge is then partially removed again in a subsequent discharge station 31.2. A developer unit 33 applies toner powder to the charged areas of the surface of the photoconductor. The toner image developed in this way is transferred to a transfer medium 34 in a transfer zone. The basic structure of the transfer medium 34 designed as a transfer roller can be seen in greater detail in Fig. 2. As illustrated in this representation, the transfer medium 34 has a roller base body 34.1. A resilient, electrically semi-conducting intermediate layer 34.2 has been applied to this roller base body 34.1. This can contain, for example, silicon, EPDM or polyurethane. An anti-adhesive coating 34.3 is arranged indirectly or directly above the intermediate layer 34.2. It constitutes the roller surface.

As Fig. 1 further shows, a transport system 10 is arranged below the transfer medium 34. It has a number of roller bodies, on which a substrate 13 can be conveyed. The transport system 10 has been arranged here in such a way that the transfer medium 34 rolls off on the surface of the substrate 13 to be imprinted. In the process, the toner powder on the

transfer medium is transferred to the substrate 13. To aid the toner transfer, a corona 12 has been integrated into a roller body of the transport system 10, which is arranged directly underneath the transfer zone.

One or several heating elements 24 is/are arranged upstream of the transfer medium in the transport direction of the substrate 13. They act on the surface of the substrate 13 and heat it evenly to a temperature within the range between 100°C and 170°C. One or several temperature sensors 21 are arranged between the heating elements 24 and the transfer medium 34 for monitoring the temperature. These emit a temperature signal to one or several regulating devices 22. The regulating device 22 reads in a predetermined value via a control device 23. The predetermined value is compared with the temperature signal in a comparator circuit. The heating elements 24 can be adjusted in case of a temperature difference. The transport speed of the transport system 10 in the area upstream of the transfer medium 34 can also be regulated to support this. It is assured in this way that the substrate 13 always enters the transfer zone with an approximately constant surface temperature.

A cooling device 35 is assigned to the transfer medium 34. It has one or several water-cooled rollers, which are in surface contact with the transfer medium 34. The rollers are connected with a heat-regulating unit 36, which removes heat energy from the transfer medium 34. The water coming from the rollers is conducted to the heat-regulating unit 36 via a circulation system. It is cooled in the temperature unit 36 and is then returned back to the rollers.

A further embodiment variation of a cooling device 35 is represented in Fig. 2. This has an air supply conduit 35.1. A gaseous cooling medium, preferably air, can be

blown through the latter onto the surface of the transfer medium 34. The air removes heat energy from the transfer medium 34. The heated fluid flow can then be aspirated off again via an air-return conduit 35.2. The air-return conduit 35.2 prevents the creation of gas flows outside the cooling zone, which can lead to damage to the toner image maintained on the transfer medium 34 or the photoconductor 32.

In a further embodiment, the core of the transfer roller consists for example of a material of good heat conductivity, such as copper, aluminum or ceramic materials, such as SiC or Si3N4, for example, and is possibly provided with cooling ribs, such as represented in Fig. 3, and is cooled by an air flow through the interior of the transfer roller. The core is coated with a flexible material of 1 to 2 mm thickness and of good heat conductivity, such as PTFE, FPM, silicon, or PUR plastic material filled, for example, with glass or a mineral material, for example.

A transfer belt with an interior blower is also conceivable, so that cooling of a large area by means of a relatively small air flow is possible.

It is advantageous if zone heating is provided over the print width in such a way that the heat output in each of the edge areas is regulated separately from the center zone. This has the advantage that the surface temperature can be better controlled over the print width and therewith the temperature constant over the print width can be improved. To this end, respective individual control devices (22) and temperature sensors (21) are assigned to each zone heating element. In this case the temperature sensors (21) advantageously consist of pyrometers which detect the surface temperature of the substrate (13). A temperature constant of ± 5 K should be attempted there.

A further embodiment provides that the substrates to be imprinted are heated in a separate, upstream-located temperature process. This takes place, for example, in a continuous throughput oven with ambient air heaters.